III.—*Collimation Error of Astronomical Instruments. By* J. G. Taylor, *Esq. H. C. Astronomer, Madras.*

Ten years have now elapsed since Captain Kater's plan for determining the position of the line of collimation by means of a floating collimator was brought before the public, and his ingenuity rewarded by the gold medal of the Royal Astronomical Society. It has happened, however, with this, as with many other great and good inventions, which are true in theory, that the application to practice is attended with so much uncertainty, as almost completely to render the plan unavailable; hence it is, that the results of observations made with the assistance of the floating collimator (if any there be) have never yet been made public. I offer these remarks with a view of saving the amateur astronomer from the vexatious disappointments which he may expect to meet with in the employment of the floating collimator; and, at the same time, of offering a plan to supersede its use, which is totally free from any sort of uncertainty: and can, moreover, be applied with much greater facility than the floating collimator; the plan in question consists of *making the telescope a collimator to itself*, by viewing the *image* of the wires reflected from a basin of quicksilver, at the *same time* that the direct image is viewed in the ordinary way through the eye-piece; to accomplish this, it is only necessary to exhibit a bright light behind the wires, so as not to interfere with the eye of the observer when applied to the eye-piece—in the case of the Madras Mural Circle, to which this principle was lately applied, I introduced a plain silver speculum into the eye-piece of the telescope between the eye-glass and the wires, having its polished surface directed towards the wires; the speculum was suspended in the cell of the eye-piece by two screws, allowing it to revolve on them as an exis, and was furnished with a small hole in the centre, through which the wires in the telescope could be seen; the telescope being now directed to the nadir to a basin of quicksilver, the speculum was turned on its axis until a ray of light (admitted through a hole about $\frac{1}{10}$ of an inch diameter, drilled in the side of the telescope), was reflected from it, and made to fall perpendicularly upon the wires (an operation occupying about five minutes to adjust, and not afterwards requiring alteration), by this means, in addition to the ordinary direct image of the horizontal wire, a reflected image was obtained, situated as much to the north of the nadir as the other was to the south, and vice versâ; nothing more was necessary now than to clamp the circle and bring the wire to cover its reflected image by the tangent screw, when the reading gave (the circle being adapted to measure north polar distance) 180° + colat. + E; subtracting the two former or 256° 55′ 50″ E., the error of collimation, became known. Since establishing the above mode of observation, which I propose to call the *reflecting collimator*, the error of collimation (or index error as it is generally called) has been read off five times every day, viz. at 6 A. M., at noon, at 6 P. M., at 8 P. M., and at midnight; taking the mean of these, the error of observation is necessarily very small, and the effect of any accidental difference of temperature in the room, which might alter the figure of the circle at any one time of the day, is at the same time greatly diminished.

To shew to what extent this mechanical measure, as it may be termed, can be depended upon, I here subjoin the result of the last ten days' observation compared with the index error determined by astronomical means, thus :

INDEX ERROR OF THE MADRAS MURAL CIRCLE.

		By the Reflecting Collimator.		*By Astronomical Observation.*		
		No. of Obs.	Index Error.	No of Obs.	Index Error.	Difference.
1835			′ ″		′ ″	
Feb.	21	5	—2·27·36	6	—2·27·39	0·03
	22	5	27·92	8	27·73	0·19
	23	5	27·64	9	27·45	0·19
	24	5	26·46	7	26·74	0·28
	25	5	27·50	7	26·50	1·00
	26	5	27·22	6	27·34	0·12
	27	5	27·28	9	27·10	0·18
	28	5	26·80	8	27·54	0·74
March,	1	5	26·91	9	27·31	0·40
	2	5	26·83	9	27·54	0·71

As a further proof of the efficiency of the reflecting collimator, I may adduce the result of observations made at this observatory with the transit instrument. Here we read off twice the sum of the errors of level and collimation, either of which being known leaves us acquainted with the other. In the case of the Madras transit instrument, which is furnished with a micrometer, giving motion to a wire parallel to the vertical wires, I have always preferred measuring the error of collimation, and computing the corrections rather than attempting by mechanical adjustment to get rid of it, as is usual with small instruments; and, on the same principle have always allowed the axis to take up its own position with regard to level; hence we have only to apply to half the micrometer-reading of the reflecting collimator, the error of level with the proper sign, and the sum or difference, as the case may be, gives the error of collimation, thus :

		Reflecting Collimation, or L+C	*Spirit Level,* or L	*Error of Collimation* by Refn. Coll.	*Ditto* by Inversion.	Difference.
1835.		″	″	″	″	″
Feb.	7	4·34	2·60	1·74	1·55	0·19
	9	4·22	2·97	1·25	1·20	0·05
	11	2·92	2·74	0·18	1·00	1·18
	11	9·80	2·74	*7·06	5·58	1·48
	12	9·28	2·41	6·87	6·73	0·14
	13	9·18	2·61	6·58	6·62	0·04
	16	9·83	2·42	7·41	6·29	1·12
	17	9·97	1·63	7·34	7·17	0·17
	18	9·89	2·04	7·85	7·20	0·65
	20	9·37	2·70	6·67	7·19	0·52

* I increased the collimation error.

The above readings of the reflecting collimator are the result of three measures occupying at most about as many minutes to make; and the collimation error by inversion is from one inversion only. As regards the wants of the amateur astronomer in India, the reflecting collimator will I apprehend be eminently serviceable, if (as is very often the case) the level attached for levelling the axis is dull in its movements, or should it unfortunately be broken; and should moreover the observer's situation preclude the erection of a mark to examine the collimation error—nothing more is necessary than a basin of quicksilver and an eye-piece fitted up as above.

We will suppose that on looking into the eye-piece the centre wire and its image are *both seen*, and that the reflected image appears 10 diameters of the wire by estimation to the *east* of the direct image; this may arise from error of level or error of collimation, or from both; to decide this question, we must invert the axis and again estimate the distance between the direct and reflected images of the centre wire—suppose the reflected image to be now situated 6 diameters of the wire to the *west* of the direct image: we have,

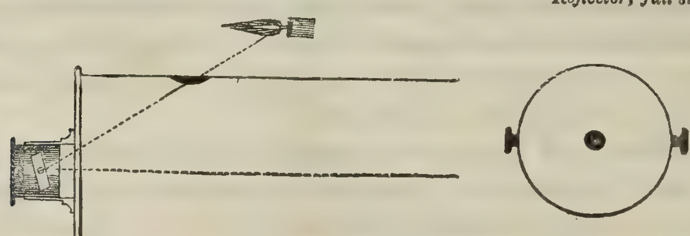
$2\ (L+C) = +\ 10$
$2\ (L-C) = -\ \ 6$ reckoning $+$ for eastern and $-$ for western deviation: from the sum we find $L = +\ 1$.

——— difference,.......... $C = +\ 4$.

Shewing that the east end of the axis is too high by a space corresponding to the thickness of the wire, and that the centre wire must be moved towards the east four times its thickness. Other instances might be adduced of the efficiency of the reflecting collimator, but the above will I apprehend be considered sufficient.

A mere glance at the accompanying figure will explain all that is necessary to the construction, which I need hardly remark can be performed by any common workman.

Reflector, full size.



Madras Observatory,
5th April, 1835.

[The elegance, the simplicity, and the great practical accuracy of the method described above by the Madras astronomer, will we have no doubt recommend it to very general adoption.—Ed.]